Plastic Fibers

Scintillating Fibers
Wavelength Shifting Fibers
Clear Fiber

Materials and Structures

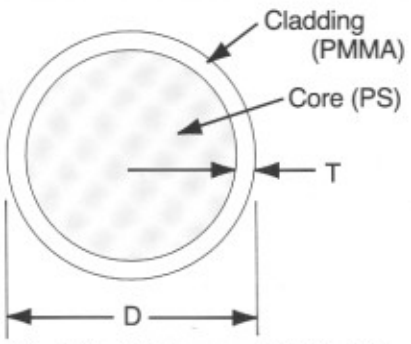
Materials

		Material	Refractive index	Density [g/cm³]	No. of atom per cm³
Core		Polystyrene (PS)	n_D=1.59	1.05	C : 4.9×10^{22} H : 4.9×10^{22}
Cladding	for single cladding inner for multi cladding	Polymethylmethacrylate (PMMA)	n_D=1.49	1.19	C : 3.6×10^{22} H : 5.7×10^{22} O : 1.4×10^{22}
	outer for multi cladding	Fluorinated polymer (FP)	n_D=1.42	1.43	

Cross-section and Cladding Thickness

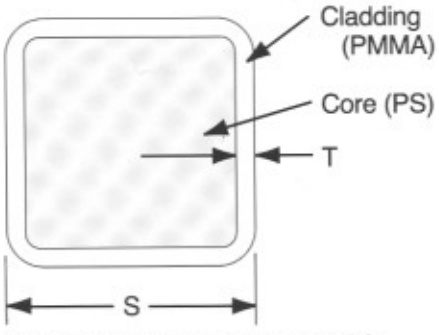
Single Cladding

Round Fiber (D)



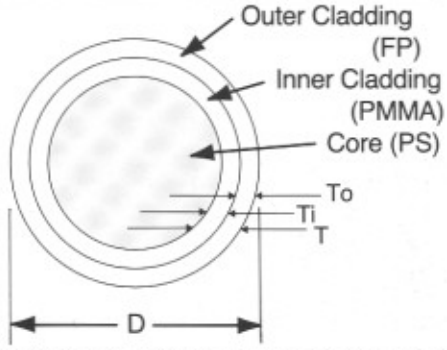
Cladding Thickness : T=3% of D
Numerical Aperture : NA=0.55
Trapping Efficiency : 3.1%

Square Fiber (SQ)



Cladding Thickness : T=2% of S
Numerical Aperture : NA=0.55
Trapping Efficiency : 4.2%

Multi Cladding (M)

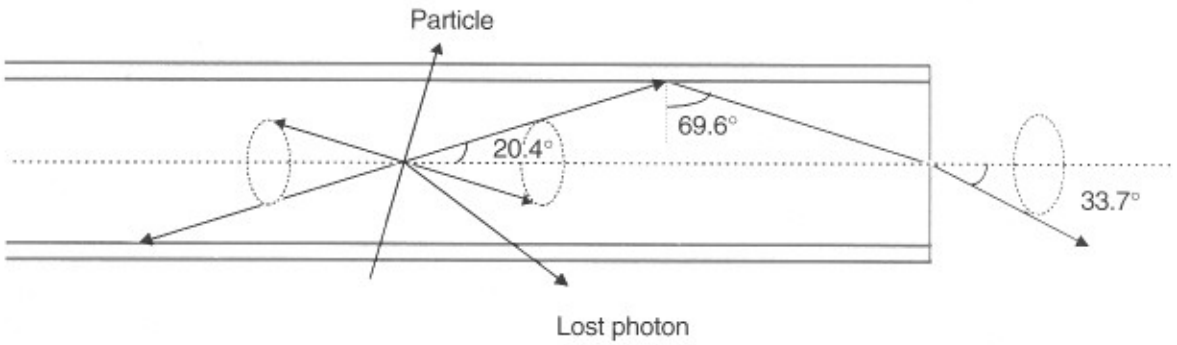


Cladding Thickness : T =3% (To)+3% (Ti)
=6% of D
Numerical Aperture : NA=0.72
Trapping Efficiency : 5.4%

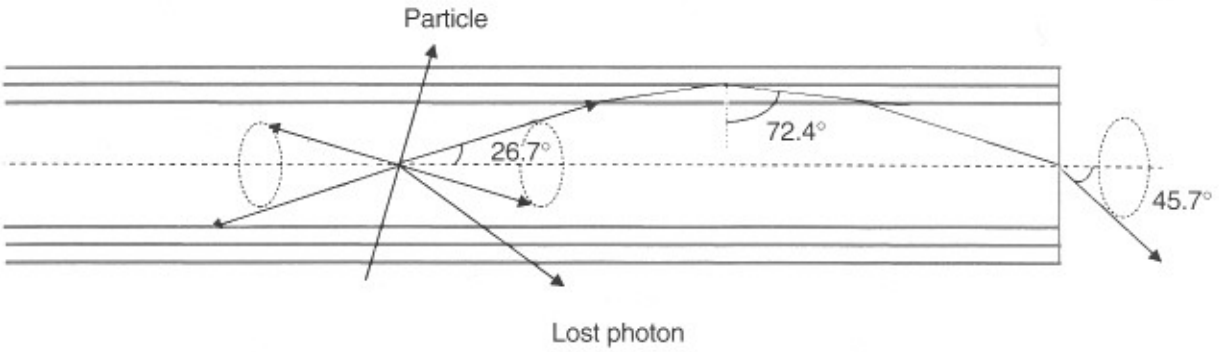
Not available

Cladding and Transmission Mechanism

Single Cladding
Single cladding is standard type of cladding.



Multi Cladding
Multi cladding fiber (M) has 50% higher light yield than single cladding fiber because of large trapping efficiency.
Clear-PS fiber of this cladding has extremely higher NA than conventional PMMA or PS fiber, and very useful as light guide fiber.
Multi cladding fiber has long attenuation length equal to single cladding fiber.



Type of Polymer Orientation of PS Core

Standard type (Non-S type)
PS core is of almost no oriented polystyrene chain and is optically isotropic and very transparent.
This conventional standard type has good attenuation length, but it showed weakness against clacking caused by bending or handling during assembling.

S type (S)
Core has molecular orientation along drawing direction.
This fiber is mechanically stronger against clacking at the cost of transparency.
The attenuation length of this type is nearly 10% shorter than standard type. (See figures on page 9)

Dimensions and Tolerance

Cross-sectional Dimension

Minimum : 0.2mm, Maximum : 2.0mm, typically as follows.
Round (Single and Multi Cladding) : 0.2, 0.5, 1.0, 1.5, 2.0mm dia.
Square (Single Cladding) : 0.2×0.2, 0.5×0.5, 1.0×1.0, 2.0×2.0mm side

Tolerance of Diameter

Cut Fiber(1~5m long) : $\left|\frac{\Delta D}{\overline{D}}\right| < 2.0\%$ for round fiber

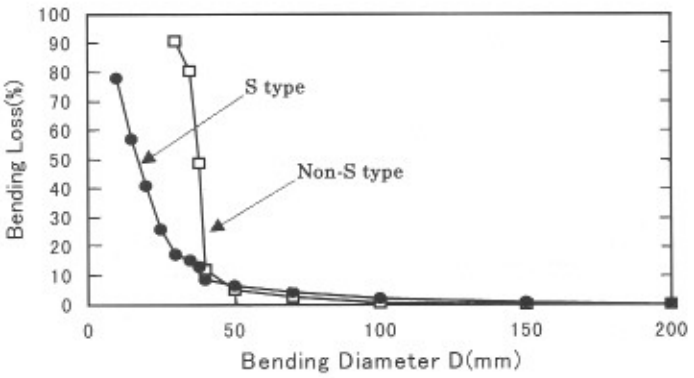
$\left|\frac{\Delta S}{\overline{S}}\right| < 3.0\%$ for square fiber

Endless Spool Fiber : $\frac{3\sigma}{\overline{D}} < 2.5\%$ (σ : rms, Spool Dia. : 300mm or 900mm.)

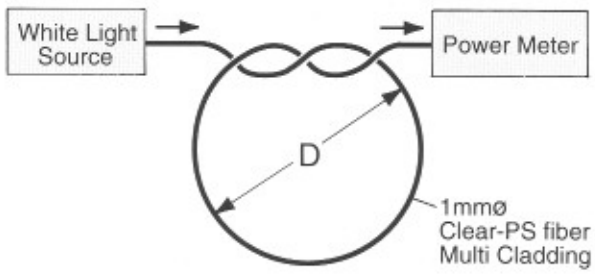
Bending Loss and Minimum Bending Diameter

Bending Loss

The following figure shows bending loss of Clear-PSM and Clear-PSMS.
S type is better than Non-S type.
The rapid increase of bending loss of non-S type is due to cracking of core.
S type doesn't show such cracking.



Measurement Method



Minimum Bending Diameter

We recommend minimum bending diameter as the following table on safety side and long term reliability.

Type	2mmø Fiber	1mmø Fiber	0.5mmø Fiber
S type	200mm	100mm	50mm
Non-S type	400mm	200mm	100mm

Formulations

Scintillating Fibers[1]

Description	Emission Color	Emission Peak [nm]	Emission Spectra	Decay Time [ns]	Att. Leng.[2] [m]	Characteristics
SCSF-81, SCSF-81M	blue	437	See the following figure	2.4	>3.5	Long Attenuation Length
SCSF-78, SCSF-78M	blue	450		2.8	>4.0	Long Att. Length and High Light Yield
SCSF-3HF(1500), SCSF-3HF(1500)M[3]	green	530		7	>4.5	3HF formulation for Radiation Hardness

1) Test fibers are Non-S type,1mmø.
2) Measured by using bialkali PMT and UV light (254nm). Quality control is made by another measurement of the transmission loss every batch.
3) For example, "3HF(1500)M" means the concentration of 3HF dye is 1500ppm, the cladding is Multi cladding.

Wavelength Shifting Fibers (WLS Fibers)[4]

Description	Emission Color	Emission Peak [nm]	Emission Spectra	Att. Leng.[5] [m]	Characteristics
Y-7 (100), Y-7 (100)M	green	490		>3.0	Green Shifter
Y-8 (100), Y-8 (100)M	green	511	See the following figure	>2.8	Green Shifter
Y-11(200),Y-11(200)M	green	476		>3.5	Green Shifter (K-27 formulation)
O-2 (100), O-2(100)M	orange	538		>1.5	Green to Orange Shifter

4) Test fibers are Non-S type,1mmø.
5)Measured by using bialkali PMT and blue LED (445nm).
Otherwise than descriptions mentioned above, various WLS fibers are available.
Ex. R-3 (green to red shifter, peak is 607nm), Y-9 (blue to green shifter, 485nm), B-1 (428nm), B-2 (437nm).

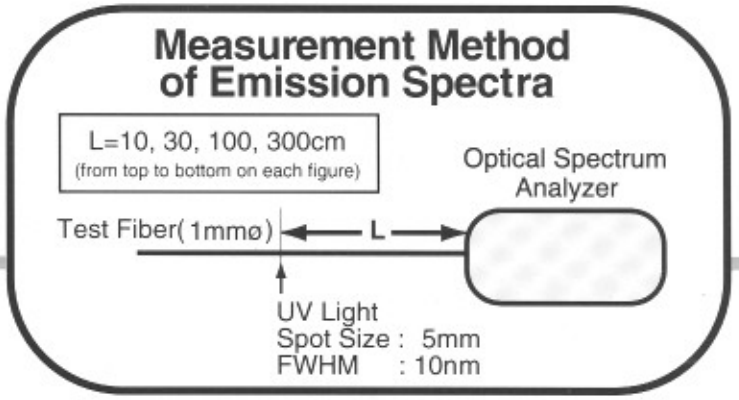
Clear Fiber (Non-doped, Optical Fiber)[6]

Description	Emission Color	Emission Peak [nm]	Emission Spectra	Att. Leng. [m]	Characteristic
Clear-PS, Clear-PSM	–	–	–	>10	depend on wavelength

6) Test fibers are Non-S type,1mmø.
Transmission Loss data is shown on page 8 and 9.

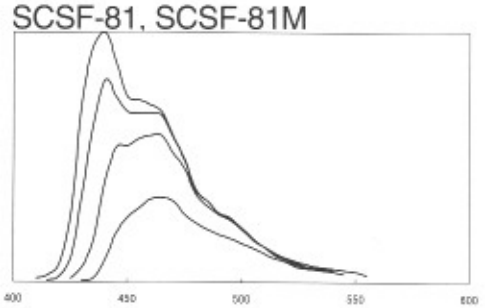
Emission Spectra

Measurement Method of Emission Spectra



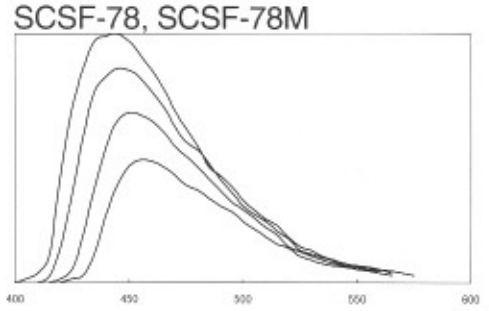
Scintillating Fibers

SCSF-81, SCSF-81M



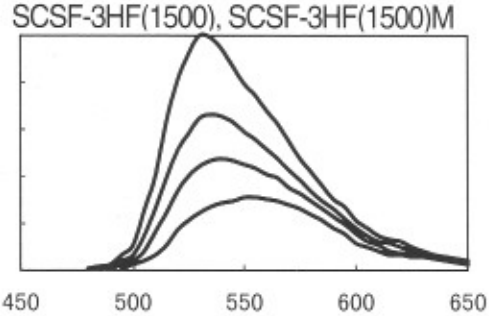
Exiting Wavelength: 370nm

SCSF-78, SCSF-78M



Exiting Wavelength: 350nm

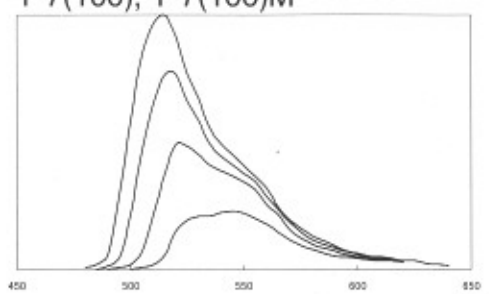
SCSF-3HF(1500), SCSF-3HF(1500)M



Exiting Wavelength: 340nm

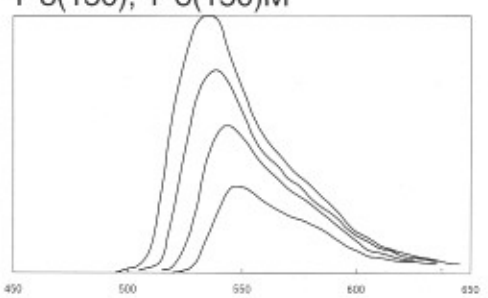
WLS Fibers

Y-7(100), Y-7(100)M



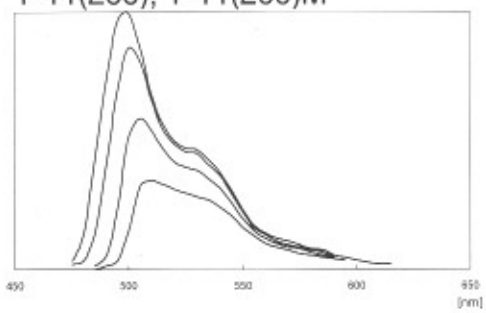
Exiting Wavelength: 440nm

Y-8(150), Y-8(150)M



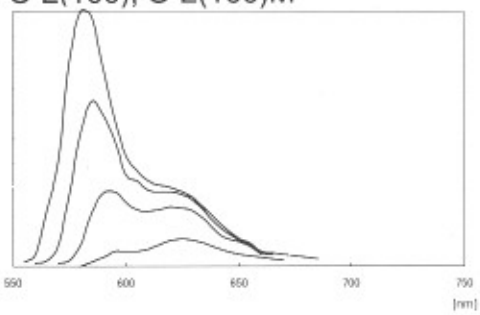
Exiting Wavelength: 455nm

Y-11(200), Y-11(200)M



Exiting Wavelength: 430nm

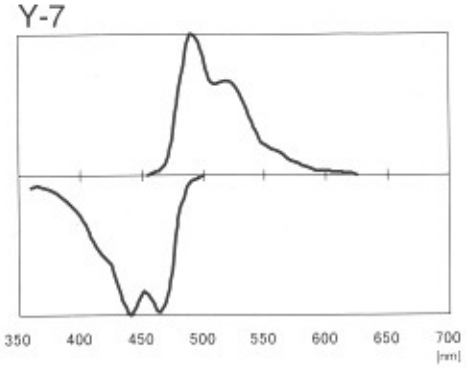
O-2(100), O-2(100)M



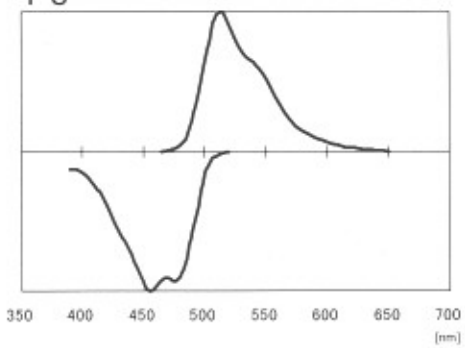
Exiting Wavelength: 430nm

Absorption and Emission Spectra of WLS 7)

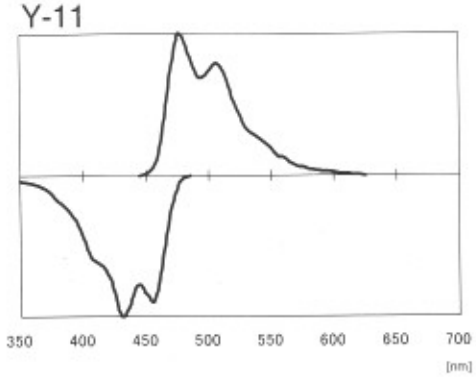
Y-7



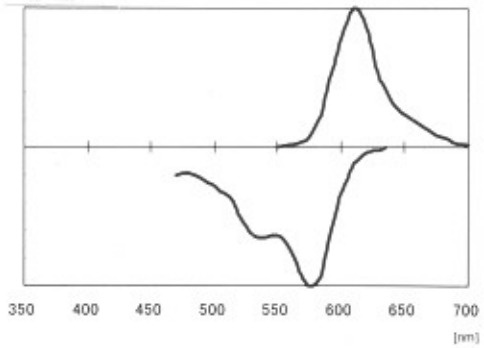
Y-8



Y-11



R-3

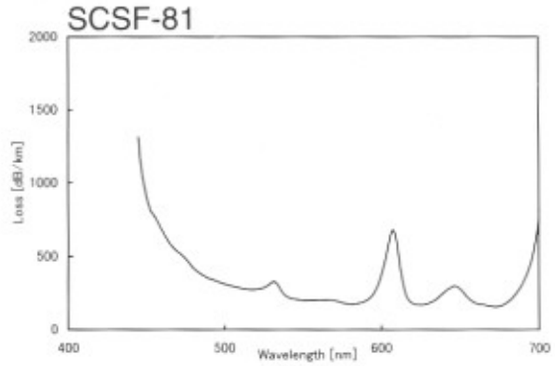


7) The spectra was measured by diluting dye with styrene monomer.

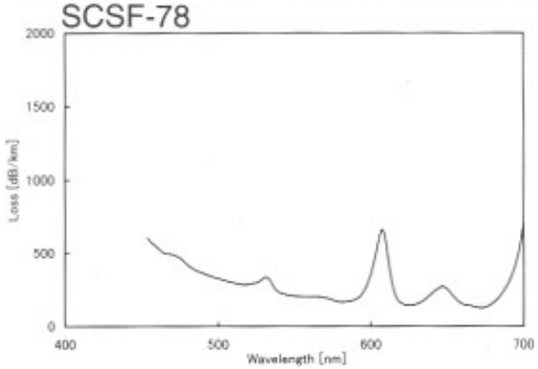
Transmission Loss

Scintillating Fibers

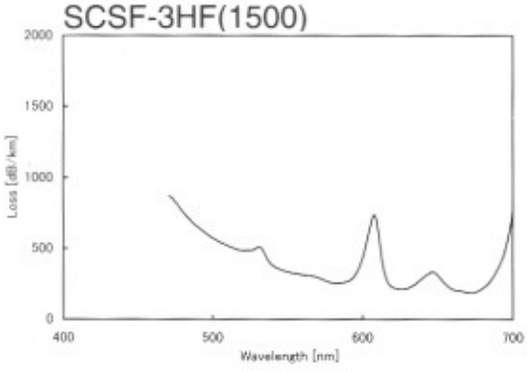
SCSF-81



SCSF-78

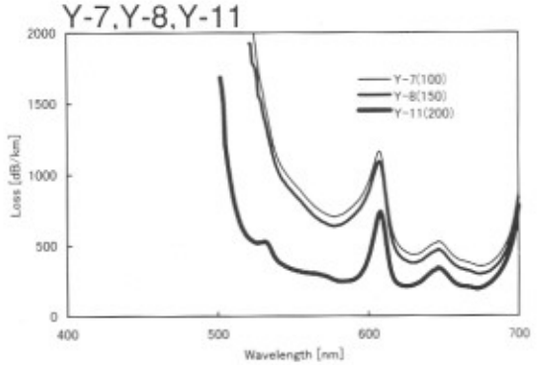


SCSF-3HF(1500)

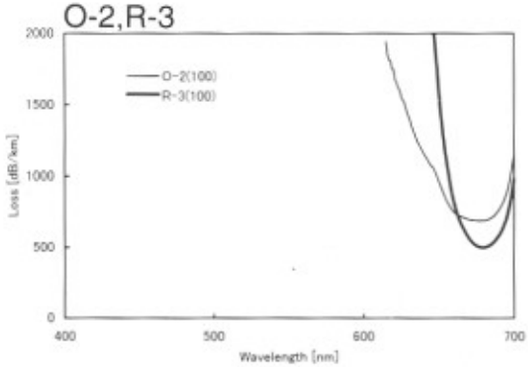


WLS Fibers

Y-7,Y-8,Y-11

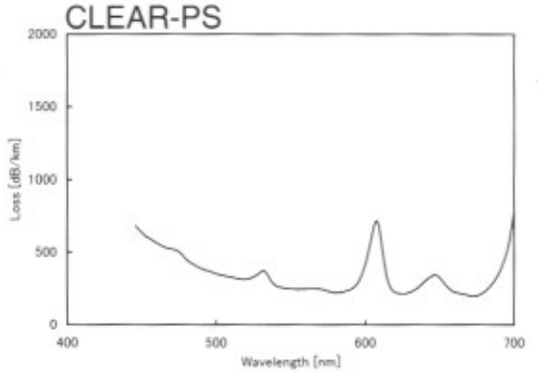


O-2,R-3



Clear Fiber

CLEAR-PS

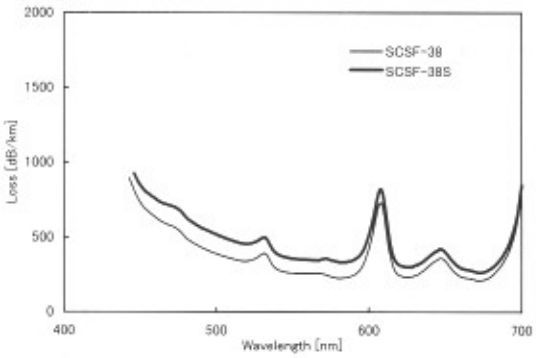


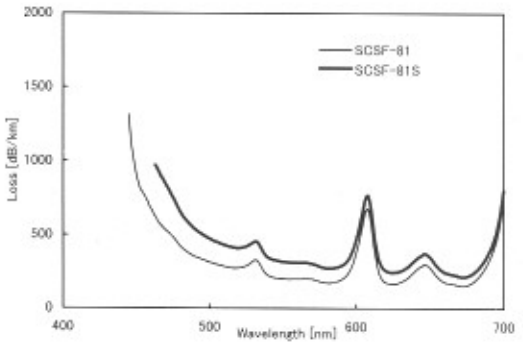
Properties of S type Fibers

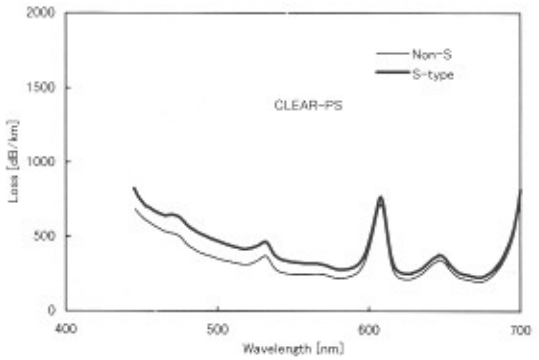
Attenuation Length

	SCSF-38S	SCSF-81S	SCSF-78S	SCSF-3HF (1500)S	Clear-PSS
Atten. Length [m]	>2.8	>3.0	>3.5	>4.0	>8.0

Transmission Loss







How to Specify Fibers

•In order to specify fibers, the following points must be clarified.
•Description •Cross-section (Round or Square) •Cladding (Single or Multi)
•Non-S type or S type •Length and Dimension •Cane or Spool
•Concentration of dye must be clarified in 3HF fiber and WLS fibers.

Examples of writing are as follows;
•SCSF-3HF(1500)M, 1.0D., 2000m on spools
→Round fiber, Multi cladding, Non-S type, 1.0mm diameter, 2000m length.
Fiber is put on spool, and the concentration of 3HF dye is 1500ppm.
•Y-11(200)S, 0.5D., 10000m on spools
→Round fiber, Single cladding, S type, 0.5mm diameter, 10000m length,
put on spools, the concentration of WLS dye is 200ppm.
•Clear-PSMS, 0.83SQ., 3m cane
→Square fiber, Multi cladding, S type, 0.83mm square, 3m length cane.